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COAL RESOURCES OF FRANKLIN COUNTY, ILLINOIS

BY
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OIL ACCUMULATION IN THE CYPRESS SANDSTONE IN THE HERALD POOL, WHITE AND GALLATIN COUNTIES, ILLINOIS

BY
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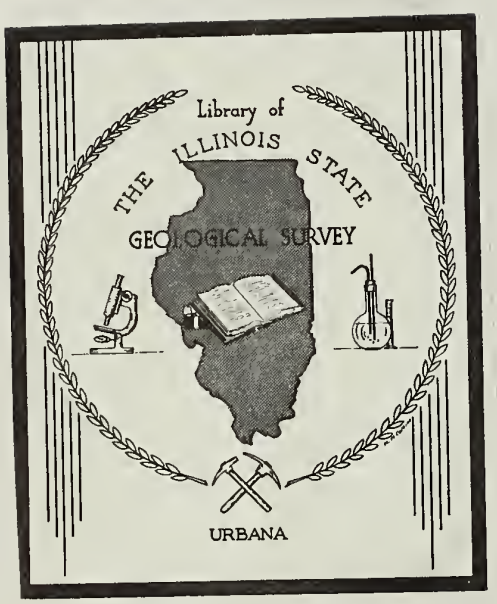

GEOLOGY

COAL RESOURCES OF FRANKLIN COUNTY, ILLINOIS*

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Franklin County, Illinois, is unique as a coal producing area in several ways: It is the only coal producing county in the State which at the start of the century had produced no coal and contained no coal mines. In 1946, however, this county produced more coal than any other county in the State—14,470,904 tons or 23 percent of the total State production for that year. Its average production per mine in 1946 of 1,113,146 tons was exceeded only by Christian County where five mines produced an average of 1,279,882 tons. One mine in Franklin County attained the highest output in the State of 2,469,470 tons, a relative position which this mine has held for 8 years and for 20 out of 22 years prior to 1947. This same mine also holds the daily output record of the State of about 15,000 tons, a record, however, which was nearly equalled by a rival mine in the county. It had the fame, at one time at least, of being the world's largest underground coal mine. Production in Franklin County is at present in the hands of five operating companies, one mine being a captive mine owned by a railroad which takes all its production.

Franklin County originally contained what appears to have been the State's largest volume of coal with a sulphur content of less than 1.25. A considerable part of this coal contained less than 1 percent sulphur. It also contains the State's thickest known bed of coal, which is 9 to 14 feet thick over considerable areas. Franklin County has probably been more thoroughly explored by the diamond drill than any other county in the State, but exploration has not often extended below No. 5 coal bed, only thirteen holes having been drilled to the greater depth, out of more than 300 that have been drilled.

The coal mined in Franklin County is produced by fewer men per ton—8.7 tons per man day in 1946—than that produced by any other county in the State except Christian which had a rating of 11.5 tons per man day for the same year. The 1946 record in neighboring Saline County, in spite of the considerable strip-mine tonnage, was 6.5 tons per man day, and for Macoupin County 7.6 tons. Fulton County, on the other hand, where most of the coal comes from strip mines produced coal in 1946 at the rate of 21.22 tons per man day.

Many more persons are employed in the coal industry in Franklin County mines than in any other county of the State, 7,402 employees being reported for 1946. The county with the next largest mine pay roll is Macoupin with 2,693 employees.

Railroads conveying coal out of Franklin County derive an annual revenue of about 20 million dollars from this service, assuming an average freight payment of $2.00 per ton. In 1946 about 10 million tons of coal were shipped on four railroads serving the county, requiring

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200,000 fifty-ton cars, or 4,000 fifty-car trains, or an average of more than 10 such train-loads daily during 1946.

The fatality record of the mines in Franklin County has fallen from the high rate of 4.89 fatalities per million tons of coal produced between 1911 and 1919 to an average of 1.11 fatalities per million tons between 1940 and 1946. This decline, although still higher than the State average of 0.4 in 1946, which is unusually low, has been brought about in spite of a highly hazardous, natural gassy condition in these mines, largely owing to the contributions to mine safety made by one of the foremost mine safety engineers in the country and a notable citizen of the county, John E. Jones. The present methods of mine rock dusting in widespread use throughout the country are largely due to Mr. Jones' ingenuity and persistence.

Over against the numerous facts pointing to the great importance of the coal mining industry and the coal resources to this region are other facts that call for the evaluation of the permanence of this industry and the availability of the coal resources. To what extent are these resources actual reserves of wealth and prosperity?

The area of the county is relatively small. This is the 66th county in respect to size, having an area of 445 square miles (284,716 acres). Furthermore, in about 14 percent of the area or 60½ square miles (38,685 acres) the No. 6 coal bed is regarded as unworkable because the bed splits into unmineable thin parts. This leaves 384½ square miles (246,031 acres) of the county underlain by workable No. 6 coal bed, assuming that a bed less than 6 feet in thickness at depths varying from about 750 to 850 feet is workable.

There is the further consideration that vigorous mining has been underway in this county about 45 years with a total output to the end of 1946 of 399,794,122 tons.

The original supply of coal in the No. 6 coal bed has been estimated on

Table 1.—Original Coal Resources in No. 6 Coal Bed in Franklin County

	Area in acres	Percent of county	Percent of productive area	Estimate 1916 Coop. Bull 15	Estimate 1934	Estimate 1948	Percent
				Millions of tons			
Split coal area	38,685	14	.....	.....	.....	.....	.....
Coal more than 8 ft. thick (Av. 9 ft. assumed)	113,970	40	47	.....	.....	1,814	54
Coal 6-8 ft. thick (Av. 7 ft. assumed)	92,162	32	37	.....	.....	1,142	34
Coal under 6 ft. (Av. 6 ft. assumed)	39,962	14	16	.....	.....	424	12
Total	284,716	.....	.....	3,718	3,282	3,381	.....

various bases from time to time (table 1) and appears to be about 3 1/3 billion tons, of which 424 million tons or 12 percent is probably less than 6 feet thick, 1,142 million tons or 34 percent is between 6 and 8 feet thick, and 1,814 million tons or 54 percent was more than 8 feet thick.

A total of 30 percent of the area underlain by No. 6 coal bed in the county, exclusive of the split-coal area (table 2) (73,454 acres or 114.8 square miles) has been mined out or rendered unmineable (fig. 1) and this area contains essentially all the coal with less than 1 percent sulphur content and much of that with less than 1.25 percent sulphur.

Most of the remaining supply of No. 6 coal bed lies in the eastern half of the county, and only two of the existing mines are probably so situated that they can mine the coal in this area within reasonable limits of cost. It is also significant that several mining ventures in the northeast part of the county north of or along the Illinois Central Railroad from Benton southeastward, found it impossible to maintain production in competition with the more favorable conditions in the mines in the western part of the county.

In spite of the evident realization on the part of the coal mining industry of the approaching depletion of the better and thicker portions of No. 6 coal bed in the western side of the county, no new mining ventures, as indicated by advanced drilling, seem to be underway in the northeastern part of the county.

In this connection attention may well be called to what appears to be an area of relatively thick coal north of Logan and in the vicinity of Bessie in an area traversed almost down the center by a branch of the Illinois Central Railroad running from the vicinity of Akin to West Frankfort (fig. 1). The position of the area is also indicated on Fig. 2 as an area where the thickness of the interval between the No. 6 coal and the first limestone is more than 10 feet. Additional drilling is necessary to prove the area but it seems to hold promise of being the only tract north of the Illinois Central Railroad branch to Eldorado in eastern Franklin Coun-

TABLE 2.—DATA ON DEPLETION OF NO. 6 COAL BED IN FRANKLIN COUNTY

	Acres	Sq. Miles
Total mineable area	246,013	384.4
(Excluding split coal: 14% of county)		
Mined out area:		
A. Actual (25%)	61,649	96.3
B. Including barriers (30%)	73,454	114.8
Total production in tons (to date of mine maps)	385,401,214 tons	
Production in tons per acre:		
A. Actual mined-out area	6,252 tons	
B. Including barriers	5,247 tons	
Thickness of coal removed (in feet):		
A. Actual mined-out area	3.53 feet	
B. Including barriers	2.96 feet	
Percentage of coal removed:		
A. Actual mined-out area		
1. 9 ft. assumed average thickness	39 percent	
2. 8½ ft. assumed average thickness	42 percent	
B. Including barriers		
1. 9 ft. assumed average thickness	33 percent	
2. 8½ ft. assumed average thickness	35 percent	

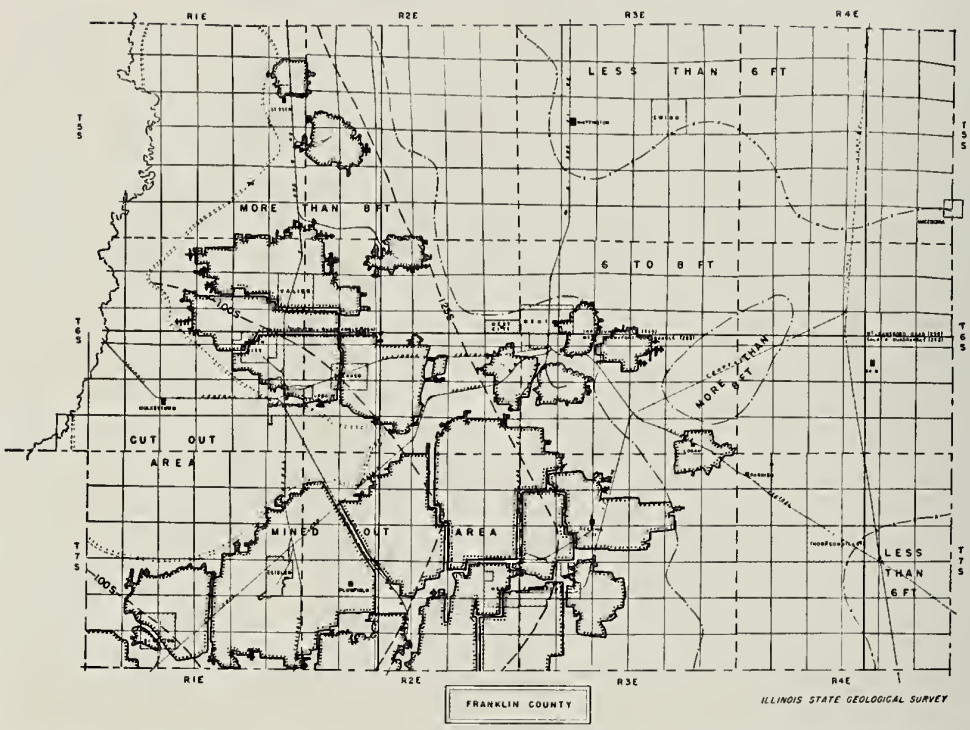

Fig. 1.—Map of Franklin County showing mined-out areas, "cut-out" area, areas in which sulphur content of No. 6 coal bed is less than 1.0 percent, between 1.0 and 1.25 percent, and greater than 1.25 percent; and areas in which No. 6 coal bed is less than 6 feet, between 6 and 8 feet, and more than 8 feet thick.

ty where there are attractive possibilities from the viewpoint of present mining requirements.

In connection with the depletion of resources in No. 6 coal bed in western Franklin County the character of recovery is of interest. The prevailing idea concerning the recovery as expressed by most engineers in the area is that this amounts to about 7,000 tons per acre. Assuming a weight for the coal of 1770 tons per acre foot (a figure long used by the State Geological Survey in coal resource studies) the recovery is equivalent to a bed almost exactly 4 feet thick (7080 tons). This recovery has been in an area where the thickness of the No. 6 bed exceeds eight feet and not infrequently is 10 feet. It seems, therefore, even on the basis of the commonly accepted figure of 7,000 tons per acre that the recovery is less than 50 percent.

Planimeter measurements of the mined-out area indicated on a small scale map (fig. 1) show that the total production of 385,401,214 tons (up to the date of the mine maps) had been taken from a mined-out area of 61,650 acres. This represents an average recovery of about 6,250 tons per acre (table 2), rather than 7,000 tons.

Recovery is not uniform in different parts of the county. Consider the three separate, more or less individually continuous areas, one in the south part of the county, one in the north part (but not including the detached mines near Sesser), and one in the eastern part (but not including the mine at Logan). The recovery (table 3) in the mined-

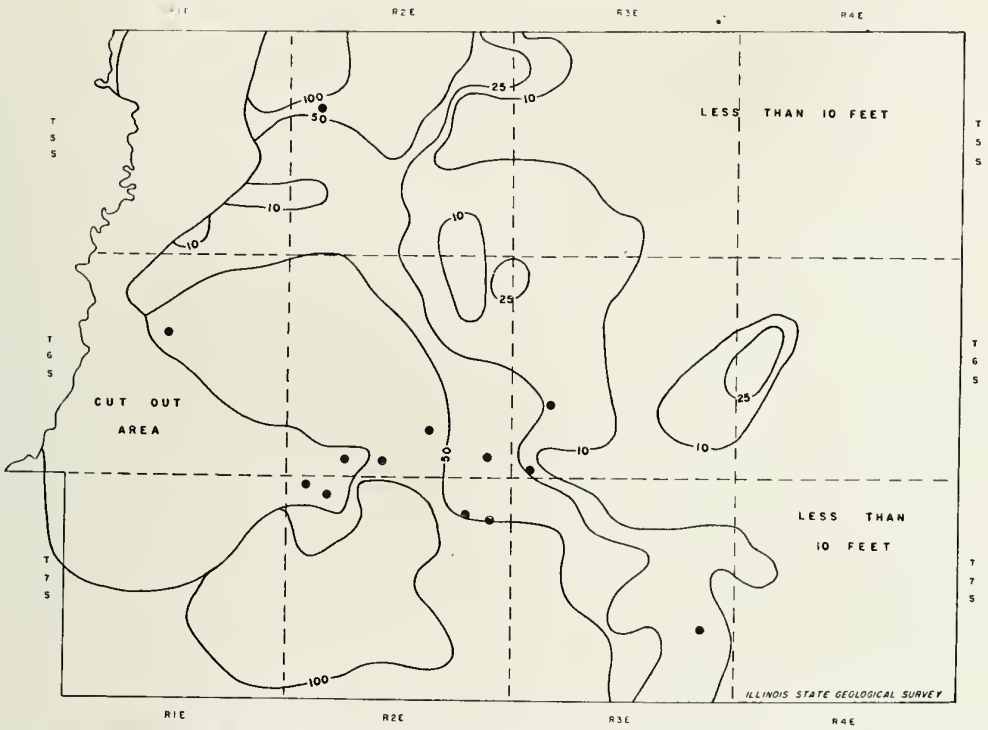

FIG. 2.—Map of Franklin County showing the distribution of variations in the interval between No. 6 coal bed and the first limestone above this coal bed, (10, 25, 50, and 100 feet) and the location of diamond-drill holes extending below No. 5 coal bed.

TABLE 3.—STUDY OF DEPLETION IN THREE SELECTED MINED-OUT AREAS IN FRANKLIN COUNTY

	Area in acres	Total production in thousands of tons	Production in tons per acre	Coal removed (feet)
North Tract				
Actual mined-out area	13,356	85,745	6,420	3.63
Including barriers	16,300	85,745	5,267	2.98
South Tract				
Actual mined-out area	41,228	265,577	6,442	3.64
Including barriers	48,000	265,577	5,533	3.12
East Tract				
Actual mined-out area	3,411	17,275	5,064	2.86
Including barriers	5,500	17,275	3,141	1.77

out southern part is at the rate of 3.64 feet, in the northern tract essentially the same, but in the eastern area is only 2.86. These figures refer only to the actual mined-out area as bounded by the extreme face. If the total area is considered, barrier pillars, town site reserves, railroad right-of-way pillars and unmined irregularities such as those along the margin of the split coal area, the figures are smaller, being 3.12 feet for the southern area, 2.98 for the northern area, and 1.77 feet for the eastern area where abandonment of the mines will undoubtedly result in high barrier-pillar loss marginal to any new operations.

The character and thickness of the No. 6 coal bed bears a definite although not fully understood relationship to the black shale and limestone caprock. Wherever the coal bed is separated from the black shale by less than about 10 feet of strata (usually by gray shale) the coal bed is rarely more than about 8 feet thick and commonly not more than 6 feet thick. The thin coal bed is characterized by a high sulphur content, usually more than 2 percent. The critical relationship, however, is not that of thickness of bed but one apparently involving the proximity of the black shale. Because of this very definite and well substantiated relationship it seems probable that the thin No. 6 coal bed in the eastern and northeastern part of the county, where the black shale and limestone lie close above the coal bed, will have a relatively high sulphur content from which it will probably be difficult but perhaps not impossible to produce the same high quality fuel as has been shipped out of Franklin County for many years.

There is at least one other matter that affects the volume of coal reserves to some extent. It is regarded as good practice to guard oil test holes by at least a 100-foot pillar, that is by a pillar not less than 200 feet in diameter. Where pools have developed in a mining area the mines and position of the drill holes are usually so planned as to reduce to a minimum the extra loss involved in an oversize pillar for an oil well or test hole. Where wells are drilled in abandoned mines or abandoned parts of mines no extra loss of coal is involved unless the well or wells get out of hand in the mine and cause disruption of mining and loss of coal or even of the mine. In the case of wildcat wells or drill-holes or where pools consist of only a few wells some loss of coal may be expected, particularly if uncertainty exists in regard to the character of the plugging. In such a case it is advisable to provide a 200-foot rather than a 100-foot pillar around the drill-hole. A 100-foot pillar contains about 1277 tons per foot of coal or about 10,000 tons for an 8-foot bed. A 200-foot pillar would contain about three times as much. There are, up to date, in the order of 75 to 100 oil test holes in the largely undeveloped eastern half of the county (fig. 3).

Brief consideration may now be given to the resources present in Franklin County in beds other than No. 6. Of these coal No. 5 (fig. 4) which lies from 30 to about 100 feet below coal No. 6 is the most important and most widespread. Its continuity is probably somewhat greater than that of No. 6 since it appears to be present under at least part of the "split-coal" area although to what extent is not well known. In general No. 5 bed is 3 to 4 feet thick, and fairly uniform in thickness. In the north part of the county there is one area where the bed is 5 feet thick, being nearly as thick as the No. 6 bed. The number of drill-holes that have penetrated to No. 5 bed is too small and the holes are too

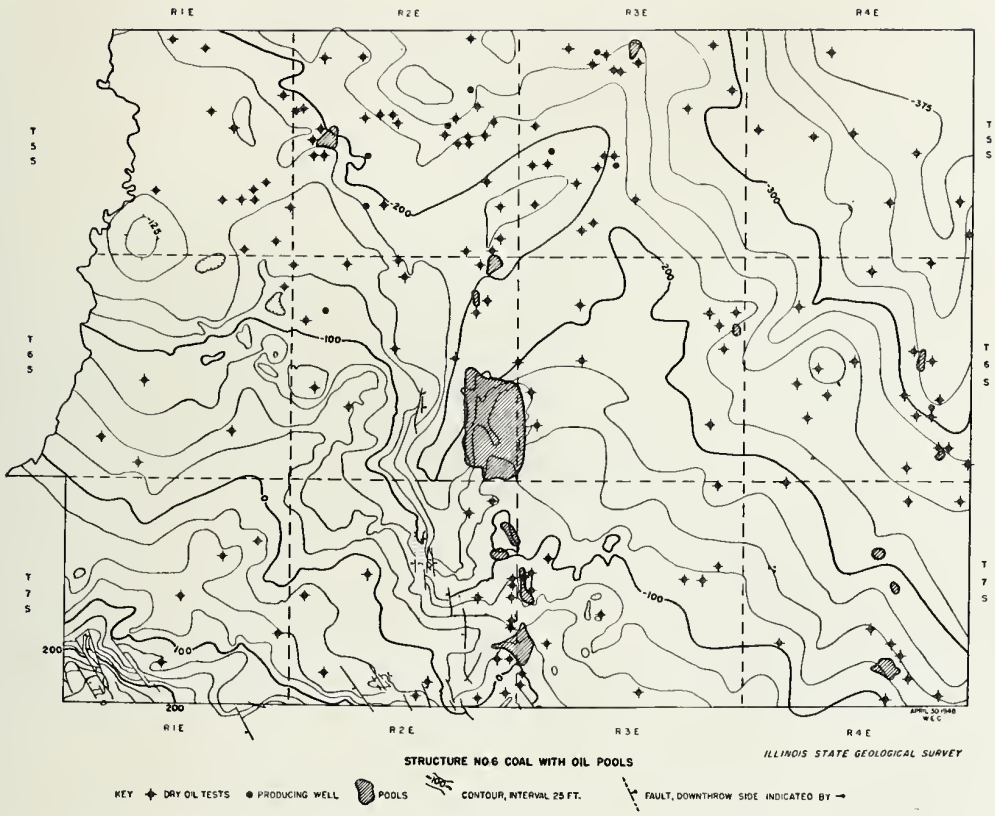

FIG. 3.—Structure of the top of No. 6 coal bed, location of oil pools, and of oil-test holes not in pools (wildcat holes).

erratically distributed to justify statements as definite in regard to the quantity of coal present in this bed as can be made in regard to No. 6 coal bed. There is particular need for more information in the northeast part of the county and in the "split-coal" area.

As a coal reserve, in the sense of a body of recoverable coal under prevailing mining conditions, the No. 5 bed has uncertain and rather doubtful value. It is very doubtful whether it can be recovered where it lies below areas of mined out No. 6 bed, particularly where the interval is less than about 50 feet. Unless mining conditions change considerably, and this possibility of course exists, the value of No. 5 coal bed as a real reserve rates low. However, in those parts of the county where the No. 6 and No. 5 bed lie 75 to 100 feet apart mining methods may be devised, as new machines become available, so that both beds can be recovered simultaneously. It seems reasonable to regard as possible the recovery of as high a proportion of the combined 10 feet of coal in the two beds as has been recovered from the single bed of the same thickness in western Franklin County. There are possibilities of improved recovery in the retreating method of mining that have not been explored but deserve trial. In any case, however, the No. 5 coal bed will probably not supply the natural premium quality of coal character-

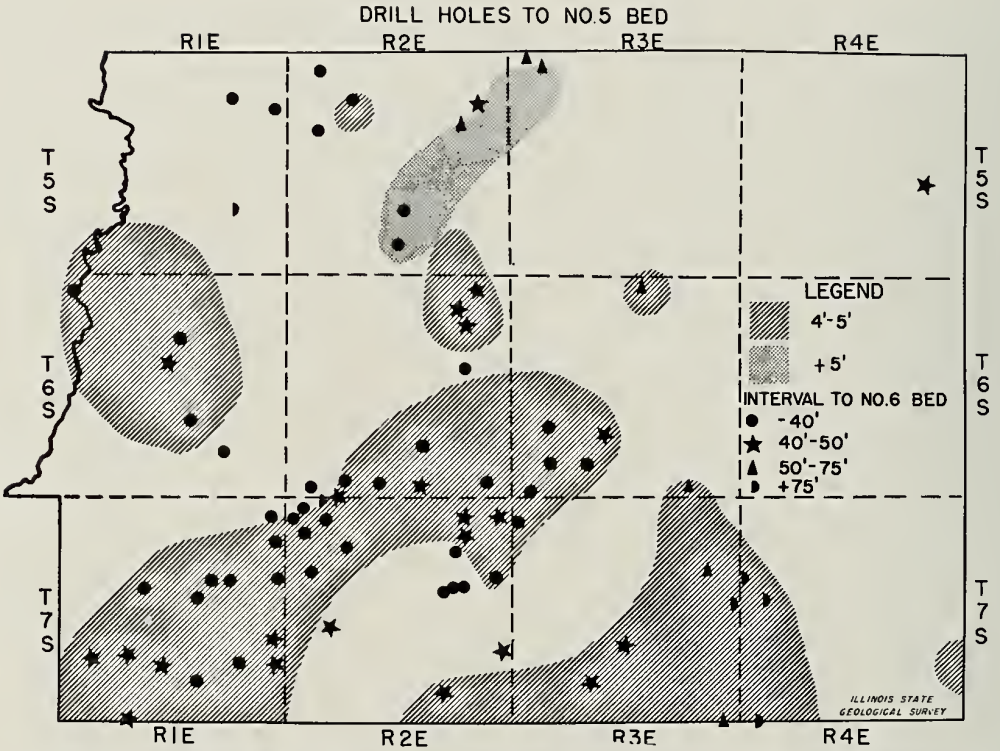

FIG. 4.—Map showing drill-holes that have penetrated No. 5 bed, distribution of variation in the thickness of the No. 5 bed, and the distribution of interval between No. 5 and No. 6 beds.

istic of the No. 6 bed where it is now being mined.

The amount of coal represented by the No. 5 coal bed in Franklin County, assuming that there are 309 square miles in which the bed averages 3½ feet thick (3 to 4 feet), 125 square miles in which it averages 4½ feet (4 to 5 feet) and 11 square miles in which it averages 5 feet (5 feet plus) is as follows:

Thickness Feet	Square Miles	Tons
3½	309	1,225,123,200
4½	125	642,297,600
5	11	63,304,000
Total		1,929,724,800

or roughly 2 billion tons. Of this 704,601,600 tons represent the coal bed where it is more than 4 feet thick. Of this area 60 square miles, in which there are 310,953,000 tons of coal, is in the area where No. 6 bed has already been mined out and the possibility of recovery of No. 5 coal is regarded by the writer as doubtful. This leaves about 400 million tons of coal thicker than 4 feet in the area where No. 6 coal has not yet been removed. Of this probably no more than about 200 million tons is recoverable, unless mining methods change considerably, which is possible.

In view of the very little information in regard to the thickness of No. 5 coal bed in the northeastern part of the county these estimates are based on an assumed thickness of 3½ feet. This estimate involves the resources in this bed for about one-quarter of the area of the county. It may be hoped that fur-

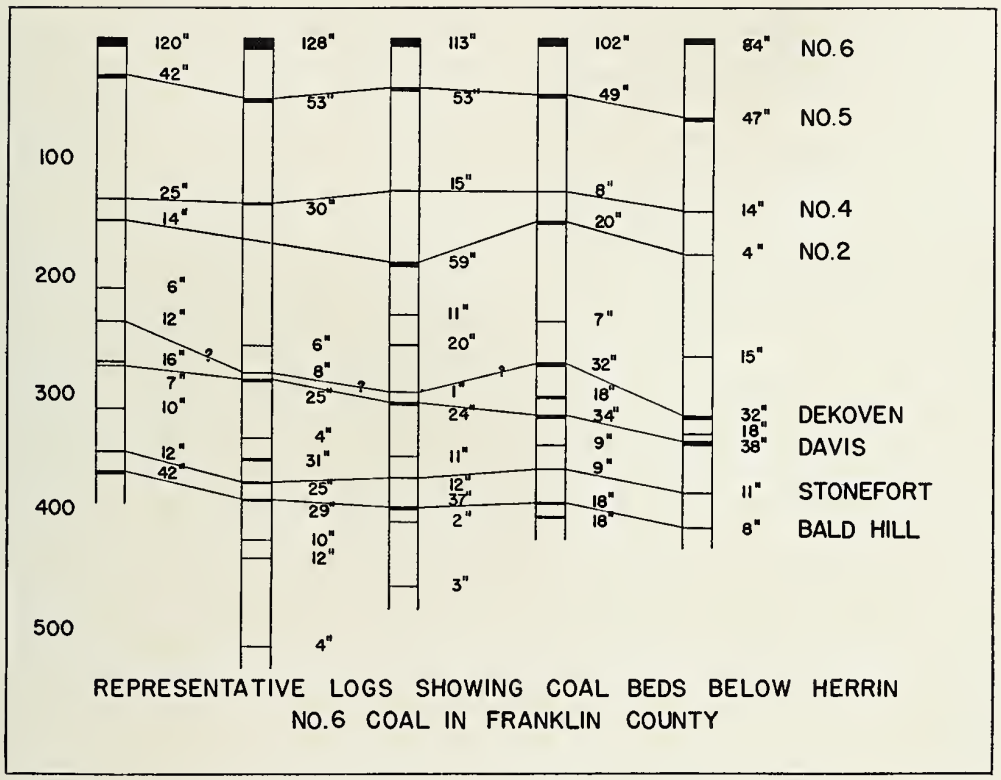

Fig. 5.—Coal beds penetrated in five selected diamond-drill holes at scattered positions in Franklin County.

ther drilling may find that this estimate is too conservative.

The coal resources of the county are not completely represented by the No. 5 and No. 6 coal beds. There are no beds exceeding about 18 inches in thickness above the No. 6 bed. The Cutler coal bed, commonly present 30 to 40 feet above the Herrin (caprock) limestone may occasionally reach 2 feet, but it is lenticular and generally unmineable. The accompanying chart (fig. 5) shows the position and thicknesses of coal beds below No. 6 bed in a group of diamond-drill holes that have been rather recently drilled here and there in the county. The amount of such deep drilling has been relatively small (fig. 2) and not scattered widely enough to provide a very satisfactory picture of the areal extent of the deep lying beds. The general conclusion that can be derived from the available information is that although occasionally coal beds 4 to 5 feet thick may be present and be penetrated in drilling, the beds are usually not thick and are characteristically lenticular and discontinuous. The two beds believed to have the widest distribution are known as the DeKoven and Davis lying between 250 and 300 feet below No. 6 bed. Even these are thin and become difficult to recognize toward the west, and even on the east side of the county are not likely to be more than 40 inches thick. The DeKoven, the upper bed of the two, is likely to be "cut out" by the overlying Palzo sandstone. The well known Murphysboro coal bed of Jackson County has not been recog-

nized with certainty among the coal beds penetrated in Franklin County. It may be either the Stonefort or Bald Hill bed. It is not the DeKoven and Davis bed as was once thought.

It is not probable that these lower coal beds will ever provide a basis for large coal mining industry such as that with which we are now familiar in Franklin County, although it cannot be said that none of these beds will ever be mined. Further drilling may discover considerable areas where one or more of these beds maintains a thickness of 4 to 5 feet. Furthermore, "ever" is a long time and man may get very desperate for fuel.

Underground gasification holds some possibility for utilizing the energy present in the thinner coal beds and in portions of the thicker beds where the quality is poor, such as in the split portions of the No. 6 coal bed. Once the No. 6 bed is entirely worked out adjacent to the "split-coal" area the development of gasification projects as a means of recovering the energy available in the split portions of the bed is a possibility that should not be overlooked. The same procedure might be applied to No. 5 and lower beds where conditions might be suitable. It is very desirable that underground gasification be tried under conditions existing in the coal fields of the middle west in order to provide a satisfactory basis for determining its applicability to these coal beds.

Conclusion

The coal resources of Franklin County may be classified into four categories: First, those resources which represent coal which can be and probably will be recovered under present conditions of mining practice and competition, the certain reserves; second, those resources represented by coal 6 to 8 feet thick which probably will be recovered, the probable reserves; third, those resources represented by a coal bed less than 6 feet thick concerning which the possibilities are doubtful. the doubtful reserves; and, finally, those resources represented by beds too thin or irregular, or both, that probably never will be worked and therefore cannot be regarded as reserves of energy or wealth.

The definite or certain reserves are represented by the approximately 897 million tons of coal in a bed 8 feet or more thick. The coal in this reserve is held very largely by two companies with a present combined output of about 10 million tons. By maintaining an unusually high rate of recovery of about 55 percent at the same annual rate of production this body of coal should last another fifty years. It is not to be expected, however, that the man power required to mine this volume of coal will continue at the present rate but that it will decrease. Accordingly the mine pay-roll in the county will undoubtedly fall from year to year partly because of the complete depletion of some of the mines and as a result of more efficient recovery in terms of tons per man day. A stepping up of the production by these two mining companies would of course tend to maintain pay-roll volume, but would shorten the life of the field.

The second category of reserves is represented by No. 6 bed where it is between 6 and 8 feet thick and by No. 5 bed where it is more than 4 feet thick. Consider No. 6 coal bed first: The probability of mining in this area containing approximately a billion and one-quarter tons of coal is affected by the absence of operating mines and the

more important unprofitable experience of companies that have undertaken such mining in the past. In general this intermediate area of the No. 6 coal bed is intermediate in other ways than in geographical position. The coal is characterized by considerable variability in quality and thickness, the sulphur content varying in short distances from relatively low to relatively high. The roof conditions provide a hazard that mining companies will hesitate to face. The interval between the coal bed and the caprock varies irregularly with lenticular bodies of gray shale commonly intervening between the coal bed and the black shale that usually lies immediately below the caprock. Cost of development will be increased by the need for more than the usual number of holes in order that irregularities may be sufficiently explored. Successful operation of this 6 to 8-foot coal bed also calls for more technical study of the roof material than has yet been applied to such rock, but considerable and possibly the best information about conditions in the area will be obtained as the mines operating in the more favored reserve area approach the margin of that area and encounter thinner coal and more irregular roof conditions. For the present at least it appears that the area of 6 to 8-foot coal should be written off as an immediate reserve, but the general thickness of the coal is such that a few improvements in mining or cleaning practice, or both, might very well throw it into the category of the immediate reserve.

With respect to No. 5 coal bed: The coal present in this bed lies in either the probable or doubtful reserves. The portion of the bed concerning which there is undoubtedly the most interest is where the bed underlies the already worked out areas of No. 6 bed because it can be reached so easily from shafts now working in the upper bed. Some of these shafts actually extend to the No. 5 bed already. It would seem as though the No. 5 bed could be worked as cheaply while operations are still active in No. 6 as after such operations cease, and failure to start such operations up to the present is not an encouraging indication of the workability of the bed.

The area of greatest promise with respect to No. 5 bed appears to be the approximately 11 square miles in the northern part of the county where the bed is more than 5 feet thick. It would seem desirable if the coal should be explored in this tract to mine both No. 6 and No. 5 beds from the same shaft. The two beds are sufficiently widely spaced and the lower coal sufficiently thick so that it might be possible to work the lower and upper beds contemporaneously in a large area in the southeastern part of the county where No. 6 coal is over 6 feet thick.

In the northeast part of the county where No. 6 coal is less than 6 feet thick both beds are 800 feet or more in depth and the coal resources in both beds rate no better than doubtful reserves although there has not been enough drilling for definite estimates.

The coal present in the beds below No. 5 coal represents a doubtful reserve. Drilling to date does not provide information sufficient to justify including such coal beds that have been encountered in either of the high categories. In certain areas there seem to be lenticular fairly thick bodies of one or more of the coal beds below coal No. 5 but no two holes seem to have penetrated coal beds as much as four feet thick at the same stratigraphic position except possibly in

the case of the Davis coal. This bed seems to be that thick only in the southeastern part of the county. It is possible that some time one or more of these beds might be found suitable for underground gasification, but it is not probable that they will be mined by shafts, except possibly in very local areas.

The present study of the status of coal resources and coal reserves in Franklin County points to the complete exhaustion of the high quality more easily mined No. 6 coal within the county in a matter of about 50 years or less. This depletion of No. 6 coal where it is more than 8 feet thick will undoubtedly be accompanied by the gradual decrease in the number of individuals supported by the mining industry in the county. It is quite possible that this decrease may take place slowly enough to cause no particular hardship. Furthermore, there is a possibility that some of the slack, should any exist, may be taken up by the start of new operations in the coal lands underlain by No. 6 bed where it is between 6 and 8 feet thick. This possibility depends a good deal upon progress made in mining methods, in improved efficiency of mining machines, in the improved understanding of the behavior of roof materials, and on improvements in mechanical devices for converting the energy in the coal into mechanical energy. Encouragement must be given to coal research in fields, such as geology, chemistry, and various branches of engineering impinging upon the coal mining industry and various aspects of coal utilization, including underground gasification.

Summary of Resource Data for No. 6 Coal Bed in Franklin County

	Acres	Percent	Square miles
The area of the county	284,716	.....	445
The "split-coal" area	38,685	14	60.5
Area exclusive of "split-coal" area	246,031	86	384.5
Area in which No. 6 coal bed has been mined or rendered unmineable	73,454	26	114.8
Total area No. 6 coal bed unavailable either mined out or in "split-coal" area	112,139	40	175.2
The available balance	172,577	60	269.8
Of the available balance area (100%)			
No. 6 coal is less than 6 feet thick in	39,962	23	62.4
No. 6 coal is 6-8 feet thick, excluding mined out area, in	90,396	52	141.2
The remaining area No. 6 more than 8 ft	42,219	25	66.0

Converted into tonnages these data signify that

The area of No. 6 less than 6 feet thick contains ..... 424,396,000 tons
The area of No. 6 between 6 and 8 feet thick contains .....1,125,887,000 tons
The area of No. 6 in which No. 6 coal is more than 8 feet thick, contains ..... 896,917,000 tons

No. 5 Coal Bed

The coal in No. 5 coal bed in Franklin County is approximately 2,000,000,000 tons. It ranges from a possible to a doubtful reserve.

OIL ACCUMULATION IN THE CYPRESS SANDSTONE IN THE HERALD POOL, WHITE AND GALLATIN COUNTIES, ILLINOIS*

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Introduction

The Herald pool is located in White and Gallatin counties in southern Illinois (fig. 1). The pool covers an area of approximately 1600 acres. Since its discovery in 1940, a total of 130 producing wells have been completed, of which 65[1] have produced oil from the Cypress sandstone. This sandstone has been chosen for study, and the discussion following is confined to it.

The Cypress is one of the lower formations of the Chester series. In the Herald pool area it consists of three sandstones, commonly with interbedded shales. The two lower sandstones are thick and fairly consistent, and sometimes separated by thin shale. It is the upper sandy zone which is productive in the Herald pool. It is an extremely variable zone of shale, sandy shale, and sandstone. The sandstone ranges from a tightly cemented sandstone to a clean permeable quartz sandstone, which is the pay zone. Normally the sandstone is overlain by shale or shaly sandstone. Occasionally the whole upper zone becomes a shale or shaly sandstone. In places there is no shale above the sandstone, so that it is directly overlain by the Barlow limestone. However, in most cases, it is the shaly layer over the pay zone which forms the caprock.

Structure

The Herald pool is in the southern part of the Illinois basin. The structure of the pool consists of three "highs," with a general north-south trend. Figure 1 shows structure contours on the base of the Barlow limestone, that is the top of the Cypress formation. In general the Cypress production is controlled by these features. The northernmost anticline is the largest of the three and has on it the largest number of wells.

Figure 2, (sec. 3, T. 7 S., R. 9 E.) shows oil accumulation in a simple structural trap. The wells high on the structure produce oil and water; those low on the structure are dry holes, often producing water with possible shows of oil. The closure of the pay is about 6 feet.

The strata in the southern part of the pool are cut by a fault or fault zone, which strikes north and northeast and dips eastward about 50° to 65°. The fault there cuts a structural high on the Cypress. On the upthrown side—the west side—the pay dips westward from the fault (fig. 3, secs. 22, 23, T. 7 S., R. 9 E.). Several wells produce oil near the fault. It is probable that the trap is sealed by an impervious bed on the opposite face of the fault which is in contact with the pay.

Depositional Variations

Although the Cypress production in the pool is generally controlled

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[1] Secs. 27, 33, 34, 35,—6S-9E; Secs. 2, 3, 4, 10, 11, 14, 15, 22, 23,—7S-9E.
Includes three wells producing from other formations also.

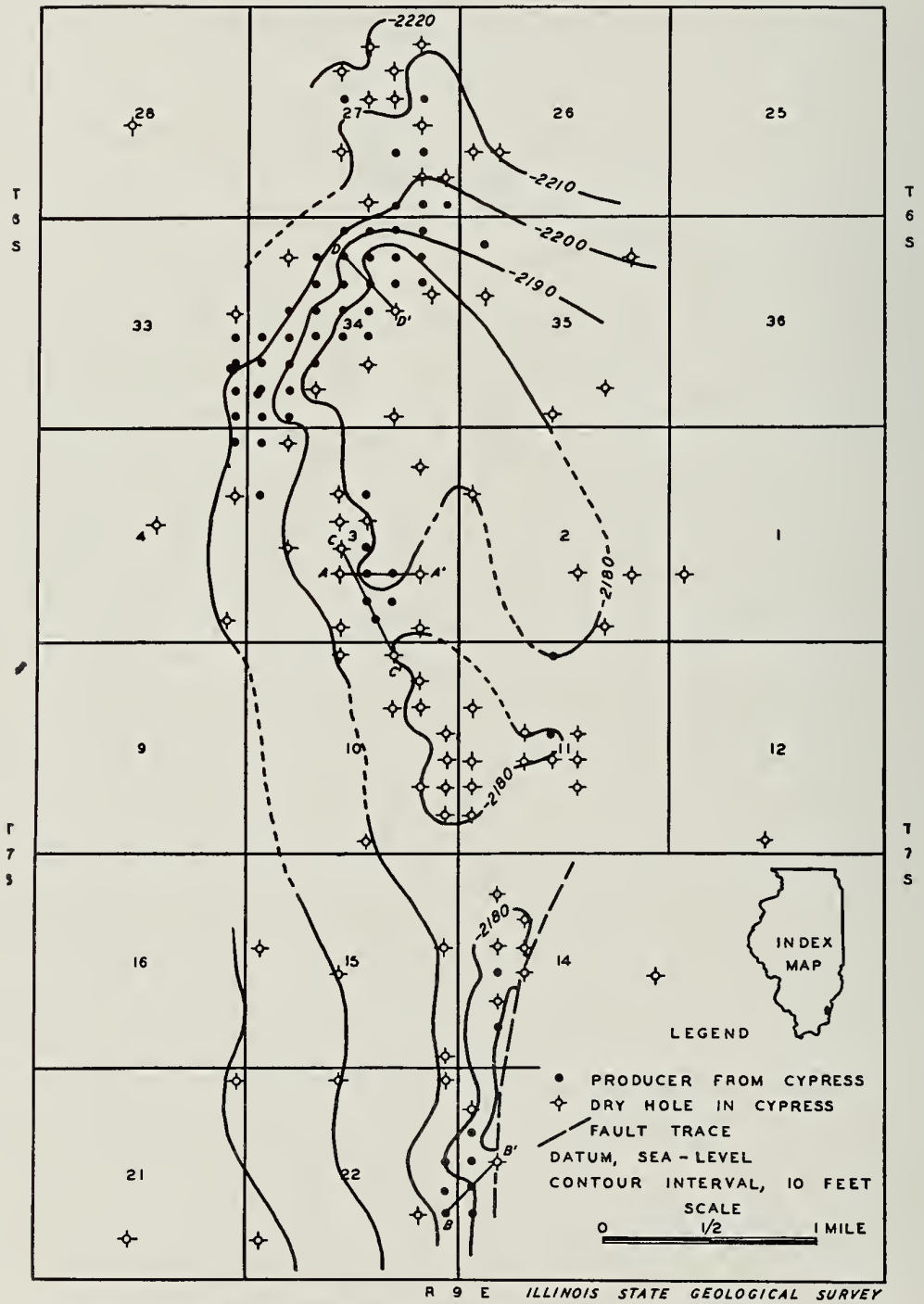

FIG. 1.—Structure map of the Herald pool. Locations of cross-sections are shown by straight lines. Index map of Illinois shows location of the pool.

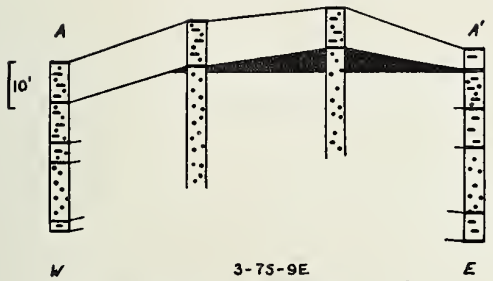

FIG. 2.—A-A′, cross-section of a structural trap.

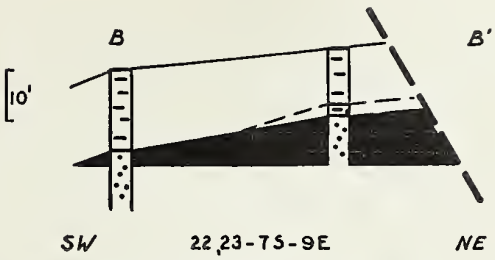

FIG. 3.—B-B′, cross-section of pay zone cut by fault.

by structure, conspicuous deviations of the production pattern from the structure pattern indicate the presence of another significant factor—depositional variations.

The shaly zone above the pay is of variable thickness. Changes in its thickness accentuate or nullify the effect of structure in forming traps. If the shale interval is fairly constant, the pay is high where the structure is high—as in the structural trap shown in figure 2. If the shale thins where structure is low, the pay there may be high. In sec. 3, T. 7 S., R. 9 E. (figure 4) such variation of shale thickness is sufficient to form a trap where the structure is low. Producers are structurally low, dry holes that produce water are structurally high.

Another important depositional variation is a change in the permeability of the pay. The sandstone may become shaly or interbedded with numerous thin shale streaks; commonly the interstitial spaces of the sandstone are filled with siliceous cement; in sandstone that is poorly sorted, the smaller grains fill the spaces between the larger ones; the sandstone may be lenticular. Such permeability changes are typical of Illinois "oil sands," where lateral variation of beds occurs commonly within a few acres, often within a few feet.

The distribution of producing wells on the anticline in sec. 34, T. 6 S., R. 9 E. is a striking illustration of the effect of permeability change, figure 5. There are many producers on the northwest flank of the anticline and several on the crest. On the highest part of the structure, however, are several dry holes. Sample studies show the pay in these wells to be shaly or cemented. The tight zone, cutting across the anticline, forms an effective seal for the oil accumulated along the flank of the structure.

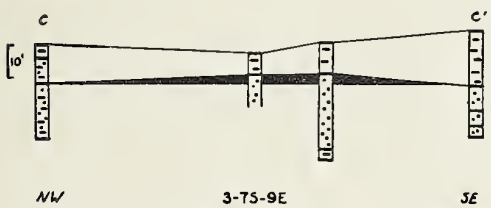

FIG. 4.—C-C′, cross-section showing effect of varying thickness of overlying shale on the trap.

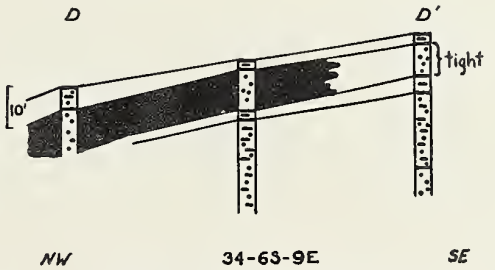

FIG. 5.—D-D′, cross-section of pay zone sealed by tight zone.

The small anticline in secs. 10 and 11, T. 7 S., R. 9 E. is a structure almost completely dry because of tightness of the sandstone. Only one well produces on this structure. The pay zone in the other holes on the anticline, though high, is shaly. The tested permeability of the sandstone in one of the highest wells averages only twelve millidarcies. Permeability of the pay in some producers in the pool averages eighty millidarcies.

These are primary features, related to conditions of deposition. In contrast, the structural features are the result of deformation.

Depositional variations on producing structures account for a number of dry holes throughout the pool.

Summary

Production from the Cypress sandstone in the Herald pool shows the effect of both structural and stratigraphic features on oil accumulation. There are examples in the pool of oil in the Cypress sandstone in the following types of traps:

Simple structural trap.
Trap sealed by an impervious bed at the fault contact.
Trap closed by thickening of overlying shale.
Trap sealed by a tight zone in the pay across an anticline.

There are also examples of areas high on structure which are dry because of depositional variations:

Thickening of overlying shale.
Tightness of producing sandstone.

Table 1.—Data for Wells on Structure Map

Location Sec.-T.-R.	Spot	Company	Farm and Well	Depth to Base of Barlow	Surface Elevation	Subsurface Elevation: Base of Barlow	Producer or Dry Hole
26-6S-9E	SW NW SW	Angle-Gilpin	Marlin 1	....	412	.....	Dry
	SE NW SW	Angle-Gilpin	Marlin 2	....	389	.....	Dry
	NE SE SE	Gilpin	Marlin 1	2617	403	–2214	Dry
27-6S-9E	SE NW SE	Shaffer-Stoll	A. B. And 1	2645	440	–2205	Producer
	NE NW SE	Shaffer-Stoll	A. B. And 2	....	...	.....	Dry
	SW SE NE	Carter	A. G. And 1	2635	431	–2204	Producer
	SW NW NE	N. V. Duncan	A. G. And 1	2643	424	–2219	Dry
	SW NE SE	Shaffer-Stoll	A. G. And 1	2641	439	–2202	Producer
	NW NE SE	Stoll	A. G. And 4	2641	432	–2209	Dry
	SE SE NW	Skelly	E. T. And 1	2704	488	–2216	Producer
	NE SE NW	Skelly	E. T. And 2	2664	453	–2211	Dry
	SE NE SW	Pure	J. And A-1	2670	457	–2213	Dry
	SE SW SE	Pure	J. And A-2	2650	447	–2203	Producer
	SW SW SE	Pure	J. And A-3	2661	453	–2208	Dry
	NE NE SW	Bates & Lichlyter	M. D. And 1	2705	495	–2210	.....
	SE SW NE	Skelly	M. D. And 1	2660	446	–2214	Dry
	SW SW NE	Skelly	M. D. And 2	2686	469	–2217	Dry
	NE SW NE	Skelly	M. D. And 3	2639	427	–2212	Dry
	SW NE NE	Carter	Austin 3	2625	411	–2214	Dry
	NW NW NW	Pure	Austin-Wilson 1	2688	443	–2245	Dry
	NE SE SE	Angle-Gilpin	Marlin 1	....	432	.....	Dry
	SW SE SE	Gilpin	Marlin 1	2605	410	–2195	Producer
	NW SE SE	Gilpin	Marlin 2	2624	424	–2200	Dry
	SE SE SE	Gilpin	Marlin 4	2614	415	–2199	Producer
28-6S-9E	NE NE SW	Amsco	Austin 1	2721	451	–2270	Dry
33-6S-9E	SE SE NE	Carter	And 1	2717	510	–2207	Dry
	NE SE SE	Pure	Holland 1	2736	538	–2198	Producer
	SE SE SE	Pure	Holland 2	2720	521	–2199	Producer
	SE NE SE	Yoder	Holland 4	2719	517	–2202	Producer
	SE NE SE	Yoder	Holland 4-A	2718	517	–2201	Producer
	NE NE SE	Yoder	Holland 5	2720	515	–2205	Producer
34-6S-9E	SE NW NW	Pure	Austin Consol. B-1	2704	496	–2208	Dry
	NW SE SW	Pure	Holland A-1	2694	516	–2178	Dry
	NE SW SW	Yoder	Holland 1	2695	508	–2187	Producer
	NW SW SW	Yoder	Holland 2	....	499	.....	Producer
	NW SW SW	Yoder	Holland 2-A	....	501	.....	Producer
	SW SW SW	Yoder	Holland 3	....	504	.....	Producer
	SE SW SW	Yoder	Holland 6	2687	501	–2186	Producer
	SE NW SW	Carter	McCallister 1	2722	532	–2190	Producer

TABLE 1.—DATA FOR WELLS ON STRUCTURE MAP—Continued

Location Sec.-T.-R.	Spot	Company	Farm and Well	Depth to Base of Barlow	Surface Elevation	Subsurface Elevation: Base of Barlow	Producer or Dry Hole
	SW NE SW	Carter	McCallister 2	2709	530	−2179	Producer
	SW NW SW	Carter	McCallister 3	2723	525	−2198	Producer
	NE NW SW	Carter	McCallister 4	2728	531	−2197	Producer
	NW NE SW	Carter	McCallister 5	2657	472	−2185	Producer
	NE NE SW	Carter	McCallister 6	2638	461	−2177	Producer
	NW NW SW	Carter	McCallister 7	2729	526	−2203	Producer
	SE SW NW	Yoder	McAllister 2	2727	524	−2203	Producer
	SW SE NW	Yoder	McAllister 3	2663	474	−2189	Producer
	SE SE NW	Yoder	McAllister 4	2618	436	−2182	Producer
	NE SE NW	Yoder	McAllister 5	2657	467	−2190	Producer
	NW SE NW	Yoder	McAllister 6	2702	504	−2198	Producer
	SW NW NE	Carter	Merritt 1	2632	453	−2179	Producer
	NW NW NE	Carter	Merritt 2	2643	452	−2191	Producer
	SE NW NE	Carter	Merritt 3	2606	429	−2177	Producer
	NE NW NE	Carter	Merritt 4	2619	429	−2190	Producer
	SW NE NE	Carter	Merritt-Webb C-80-1	2606	423	−2183	Producer
	NW NE NE	Carter	Merritt-Webb C-80-2	2628	429	−2199	Producer
	SE SW SE	Gilpin	Newcomb 1	2654	479	−2175	Dry
	SE NE NW	Texas	Pool 1	2635	448	−2187	Producer
	NE NE NW	Texas	Pool 2	2684	482	−2202	Producer
	SW NE NW	Texas	Pool 3	2647	445	−2202	Producer
	NW NW SE	Pure	B. Weasel 1	2638	463	−2175	Producer
	SW NW SE	Pure	B. Weasel 2	2649	478	−2171	Dry
	C SE NE	Carter	C. Weasel 1	2581	409	−2172	Dry
	SW SW NE	Carter	C. Weasel 2	2614	440	−2174	Producer
	NW SW NE	Carter	C. Weasel 3	2598	417	−2181	Producer
	NE SW NE	Carter	C. Weasel 4	2584	410	−2174	Producer
	NW SE NE	Carter	C. Weasel 5	2578	405	−2173	Producer
	SE SW NE	Carter	C. Weasel 6	2633	458	−2175	Dry
35-6S-9E	SE SE SW	Carter	And 1	2625	441	−2184	Dry
	C SW NW	Carter	Marlin 1	2638	456	−2182	Dry
	NE SW SE	McBride	Porter 1	2604	419	−2185	Dry
	SW NE NE	Slagter	Questell 1	2634	433	−2201	Dry
	C NW NW	Carter	Webb C-81-1	2593	397	−2196	Producer
1-7S-9E	SW NW SW	Kingwood	Pyle 1	2917	497	−2420	Dry
2-7S-9E	NW SW NW	Kingwood	Bayley 1	2690	510	−2180	Dry
	SE SW SE	McCummings	Bayley 1	2668	481	−2187	Dry
	330SL, 410WL, NE SE	McGraw-Simon	Dagley 2	....	492	.....	Dry
	SW NW SE	Carter	Questell 1	2664	491	−2173	Dry

TABLE 1.—DATA FOR WELLS ON STRUCTURE MAP—Continued

Location Sec.-T.-R.	Spot	Company	Farm and Well	Depth to Base of Barlow	Surface Elevation	Subsurface Elevation: Base of Barlow	Producer or Dry Hole
3-7S-9E	SW NE NE	Gilpin	And 1	2667	490	–2177	Dry
	SW NE SE	McBride	And 1	2655	472	–2183	Dry
	NW NW NW	Carter	Bayley 1	2673	480	–2193	Producer
	NE NW NW	Carter	Bayley 2	2669	474	–2195	Dry
	NW SW NE	Gilpin et al	Bayley 1	2670	494	–2176	Producer
	SW SW NE	Gilpin	Bayley 2	2669	488	–2181	Dry
	NW NW SE	Gilpin	Bayley 3	2680	497	–2183	Producer
	SW NW SE	Gilpin	Bayley 4	2670	493	–2177	Producer
	SE NW SE	Gilpin	Bayley 5	2669	495	–2174	Producer
	580SL, 580WL, SE	McBride	Bayley 1	2675	491	–2184	Producer
	SW SE SE	McBride	Bayley 2	2666	477	–2189	Dry
	NW SW SE	McBride	Bayley 3	2697	510	–2187	Producer
	NE SW SE	McBride	Bayley 4	2673	490	–2183	Producer
3-7S-9E	NW SW NW	Q. B. Mitchell	Fulkerson et al-1	2722	530	–2192	Producer
	SE SE SW	Tidewater	Millikan 1	2659	470	–2189	Dry
	NE SE NW	Fox & Fox	O'Neal 1	....	496	.....	Dry
	SE SE NW	Fox & Fox	O'Neal 2	2677	491	–2186	Dry
	NE NE SW	Kingwood	O'Neal 1	2677	493	–2184	Dry
	SE NE SW	Kingwood	O'Neal 2	2682	497	–2185	Dry
	NE NW SW	Mitchell	O'Neal 1-B	2708	519	–2189	Dry
4-7S-9E	NE NE NE	Pure	Holland B-1	2726	528	–2198	Producer
	NE SE NE	Pure	Holland B-2	2709	514	–2195	Dry
	560SL, 560EL,	McBride	Millikan 1	2640	441	–2199	Dry
	SW SW NE	Carlson	Orr-Fulkerson	....	515	.....	Dry
10-7S-9E	NW SE NE	Kingwood	Bayley 1	2614	438	–2176	Dry
	SE SE NE	Kingwood	Bayley 2	2612	436	–2176	Dry
	NE NE NW	Shulman Bros.	Bayley 1	2643	454	–2189	Dry
	NE NW NE	Mabee	Harris 1-A	2652	472	–2180	Dry
	SW NE NE	Carter	Hendrix 1	2624	444	–2180	Dry
	NE NE SE	Kingwood	Knight 1	2614	439	–2175	Dry
	SE NE SE	Kingwood	Knight 2	2617	444	–2173	Dry
	NE SE SE	Kingwood	Knight 3	2612	434	–2178	Dry
	SW NE SE	Kingwood	Knight 4	2613	432	–2181	Dry
	SW SW SE	Mabee	Knight 1	2608	417	–2191	Dry
	NE SW NE	Carter	Weas 1	2623	436	–2187	Dry
11-7S-9E	NW NW SW	Gulf	Bayley 1	2607	430	–2177	Dry
	SW NW SW	Gulf	Bayley 2	2603	427	–2176	Dry
	NW NE SW	Gulf	Bayley 3	2617	438	–2179	Dry
	NW SW SW	Gulf	Bayley 4	2598	419	–2179	Dry

TABLE 1.—DATA FOR WELLS ON STRUCTURE MAP—Concluded

Location Sec.-T.-R.	Spot	Company	Farm and Well	Depth to Base of Barlow	Surface Elevation	Subsurface Elevation: Base of Barlow	Producer or Dry Hole
	NE NE SW	Gulf	Bayley 5	2613	432	–2181	Dry
	NW SW NW	Kingwood	Bayley 3	2637	462	–2175	Dry
	NW NW SE	Leach	Bayley 1	2607	424	–2183	Dry
	SW NW SE	Leach	Bayley 2	2619	431	–2188	Dry
	SW SW NE	Carter	Dagley 2	2623	437	–2186	Dry
	NE NE NW	Bennett Bros.	Questell 1	....	479	.....	Dry
	SW SE NW	Lewis	Questell 1	2622	442	–2180	Dry
	SE SE NW	McCummings	Questell 2	2617	438	–2179	Producer
	300NL, 330EL, NE NW	McCummings	Questell 6	2662	482	–2180	Producer
12-7S-9E	SE SE SW	Wilson	Dagley 1	2745	417	–2328	Dry
14-7S-9E	NE SW SW	Oil Management	Bayley 1	2577	407	–2170	Producer
	SE SW NW	Oil Management	Harrell 1	2606	433	–2173	Dry
	SW SE NW	Oil Management	Harrell 3	2603	423	–2180	Dry
	NW SE NW	Oil Management	Harrell 4	2617	439	–2178	Dry
	SE NW NW	Carter	Knight 1	2618	432	–2186	Dry
	NW NE SW	Oil Management	Williams 1	2634	394	–2240	Dry
	SE NW SW	Oil Management	Williams 2	2578	405	–2173	Dry
	NE NW SW	Oil Management	Williams 3	2582	404	–2178	Producer
	NE NE SE	Spires	Williams 1	2719	396	–2323	Dry
15-7S-9E	SE SE SE	Phillips	Bourland 1	2633	445	–2188	Dry
	SE SE NE	Phillips	Bourland 2	2591	402	–2189	Dry
	SW SW NW	Anderson	Knight 1	2603	400	–2203	Dry
	NE NE SW	Self	Knight 1	....	412	.....	Dry
21-7S-9E	NE NE NE	Skelly	Hale 1	2611	404	–2207	Dry
	NE SE SW	Ryan	Mills 1	2596	387	–2209	Dry
22-7S-9E	SW NE SE	Aetna & Oil Management	T. H. Boyd 2	2607	411	–2196	Dry
	NE NE SE	Aetna & Oil Management	T. H. Boyd 4	....	402	.....	Producer
	SE NE SE	Aetna & Oil Management	T. H. Boyd 5	2586	401	–2185	Producer
	NW SW SW	Carter	Hale 1	2632	413	–2219	Dry
	NE NE NE	Fryer	Jones 1	....	428	.....	Dry
	SE SE NE	Oil Management	Jones 2	2593	414	–2179	Producer
	NE NE NW	N. V. Duncan	Knight 1	2613	412	–2201	Dry
23-7S-9E	SW NW NW	Fryer	C. H. Boyd 2	2588	399	–2189	Dry
	NW SW NW	Red Bank	C. H. Boyd 1	2567	394	–2173	Producer
	SW SW NW	Red Bank	C. H. Boyd 2	2568	390	–2178	Producer
	SE SW NW	Red Bank	C. H. Boyd 3	2709	389	–2320	Dry
	SW NW SW	Claude Neon Lights	T. H. Boyd 2	....	390	.....	Producer
	NW NW SW	Red Bank	T. H. Boyd 1	2571	390	–2181	Producer